September 23, 2004

NASA Electronic Parts and Packaging Program

Evaluation of 1N4148 Small Signal Diodes and 1N5819 Schottky Rectifiers Under Extreme Temperatures

Richard Patterson, NASA Glenn Research Center
Ahmad Hammoud, QSS Group, Inc. / NASA GRC
Malik Elbuluk, University of Akron

Scope

This report summarizes the preliminary results obtained on the evaluation of 1N4148 small signal diodes and 1N5819 Schottky rectifiers under extreme temperatures. The investigations were carried out to establish a baseline on functionality and to determine suitability of these devices for use in space applications under cryogenic temperatures. These devices were chosen because they are being considered by the NASA Jet Propulsion Laboratory (JPL) for use in electronic circuits on future space missions.

Test Procedure

The devices investigated in this work comprised of Fairchild's 1N4148 small signal diodes and 1N5819 Schottky rectifiers. Two devices of each type of diode were examined for operation between -195 °C and +20 °C. Performance characterization was obtained in terms of their voltage-current characteristics, using a Sony/Tektronix 370A programmable curve tracer, at specific test temperatures. Cold-restart capability, i.e. power switched on while the devices were at a temperature of -195 °C, was also investigated. A temperature rate of change of 10 °C per minute was used, and a soak time of at least 20 minutes was allowed at every test temperature. The effects of thermal cycling under a wide temperature range on the operation of these diodes were also investigated. The diodes were exposed to a total of 10 cycles between -195 °C and +100 °C at a temperature rate of 10 °C/minute. Following the thermal cycling, measurements were then performed at the test temperatures of +20, -195, +100, and again at +20 °C. Table I shows some of the manufacturer's specifications for these devices [1].

Table I. Manufacturer's specifications of diodes [1].

Parameter	**Symbol**	**1N4148**	**1N5819**
Average Forward Current (A)	$I_{F(AV)}$	0.2	1
Non-repetitive Forward Current (A)	I_{FSM}	1 - 4	25
Forward Voltage (V)	V_F	0.6 – 1.0	0.6 – 0.9
Max. Repetitive Reverse Voltage (V)	V_{RRM}	100	40
Power Dissipation (W)	P_D	0.5	1.25
Operating Temperature (°C)	T_J	-65 to +175	-65 to +125

Test Results

Although two devices of each of the 1N4148 small signal diode and the 1N5819 Schottky rectifier were evaluated, data pertaining to only one of each of these devices are presented due to the similarity in their results.

Temperature Effects

Figure 1 shows the forward voltage-current characteristics of the 1N4148 small signal diode at test temperatures of 20, -50, -75, -100, -125, -150, -175, and -195 °C. It can be seen that the diode maintained operation throughout this test temperature range. Its forward voltage, however, increased with decrease in temperature. For example, while the forward voltage had a value of about 0.7 V at room temperature, it increased to slightly over 1 V at the extreme cryogenic temperature of -195 °C. The on-resistance (R_{ON}) of the diode also was influenced by the change in temperature. As can be seen in Figure 1, the resistance exhibited very slight decrease, as reflected in the steepness of the curves, at lower temperatures.

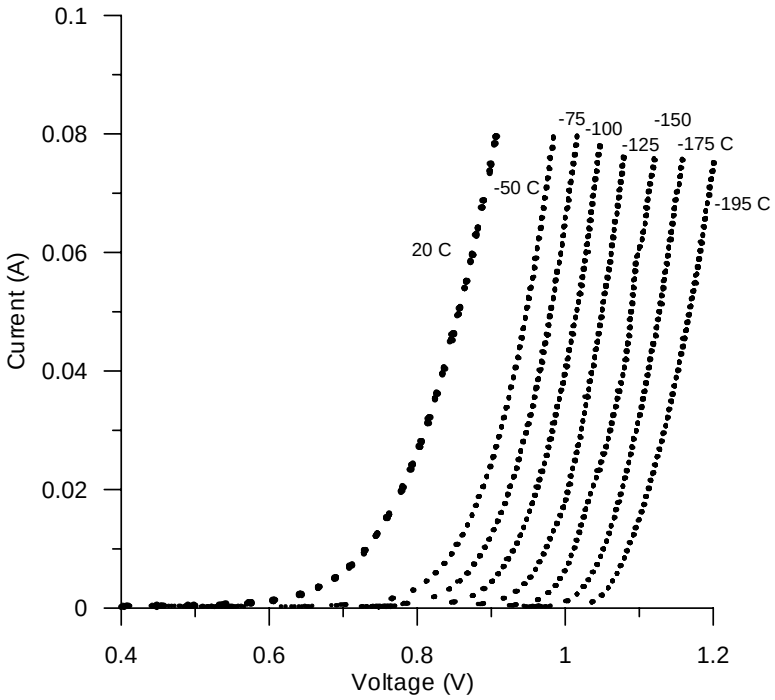

Figure 1. Forward voltage-current characteristics of a 1N4148 diode as a function of temperature.

Similar to the 1N4148 small signal diode, the 1N5819 Shottky rectifier maintained operation throughout this test temperature range, and its forward voltage increased with a decrease in test temperature. Figure 2 depicts the forward voltage-current characteristics of this device at temperatures of 20, -50, -75, -100, -125, -150, -175, and -195 °C. It can be seen that the forward voltage increased from about 0.25 V at +20 °C to about 0.53 V

at -195 °C. In addition, the on-resistance (R_{ON}) of this diode exhibited slight decrease with decrease in test temperature.

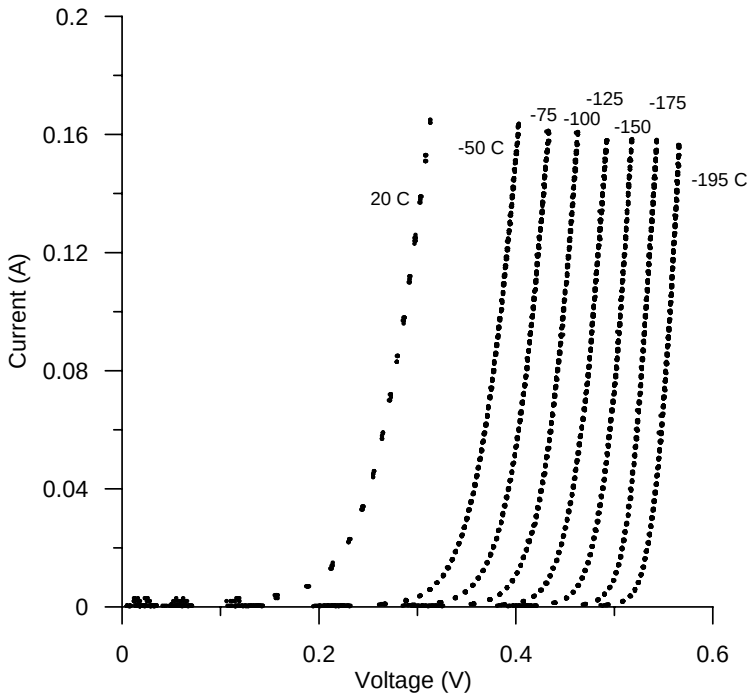

Figure 2. Forward voltage-current characteristics of a 1N5819 diode as a function of temperature.

Cold Re-Start

Cold-restart capability of the 1N4148 small signal diodes and 1N5819 Schottky rectifiers was investigated by allowing the devices to soak at -195 °C for 20 minutes without electrical bias. Power was then applied to the device under test, and measurements were taken on the forward voltage-current characteristics. All diodes did perform cold start at -195 °C, and the results obtained were similar to those obtained earlier at that temperature.

Effects of Thermal Cycling

The effects of thermal cycling under a wide temperature range on the operation of the diodes were investigated by subjecting them to a total of 10 cycles between -195 °C and +100 °C at a temperature rate of 10 °C/minute. Data on the voltage-current characteristics for the diodes were taken at +20 °C before cycling, and at -195, +100, and +20 °C after the thermal cycling. No major changes were observed, for either device, in the forward voltage-current characteristics due to this limited cycling. Figures 3 and 4 depict the forward voltage-current characteristics of the 1N4148 small signal diode and 1N5819 Schottky rectifier, respectively. It is important to note that the forward voltage for both devices decreased when test temperature increased to +100 °C; and at -195 °C, the curves were exact to those prior to the thermal cycling. In addition, the measurements that were taken at +20 °C indicate that all diodes exhibited full recovery

after the thermal cycling. This limited thermal cycling also appeared to have no effect on the structural integrity of these devices as none underwent any structural deterioration or packaging damage.

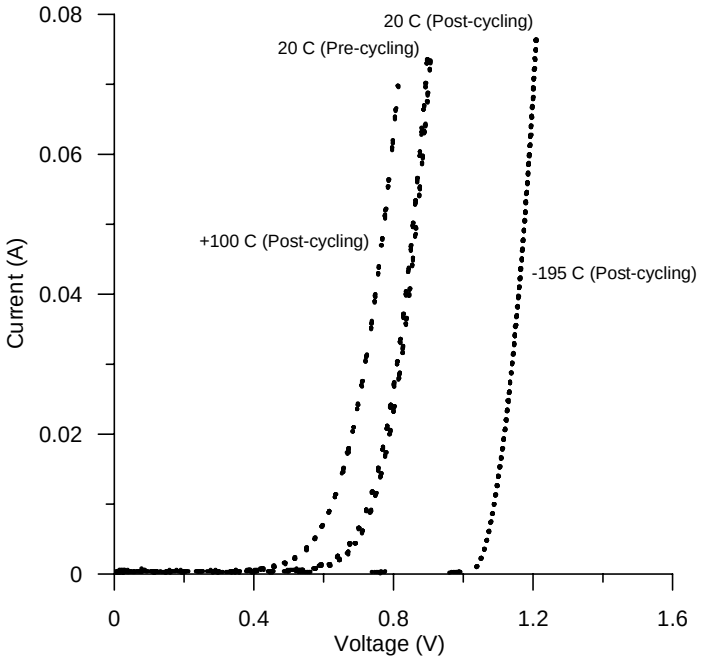

Figure 3. Forward V/I characteristics of a 1N4148 diode as a function of temperature.

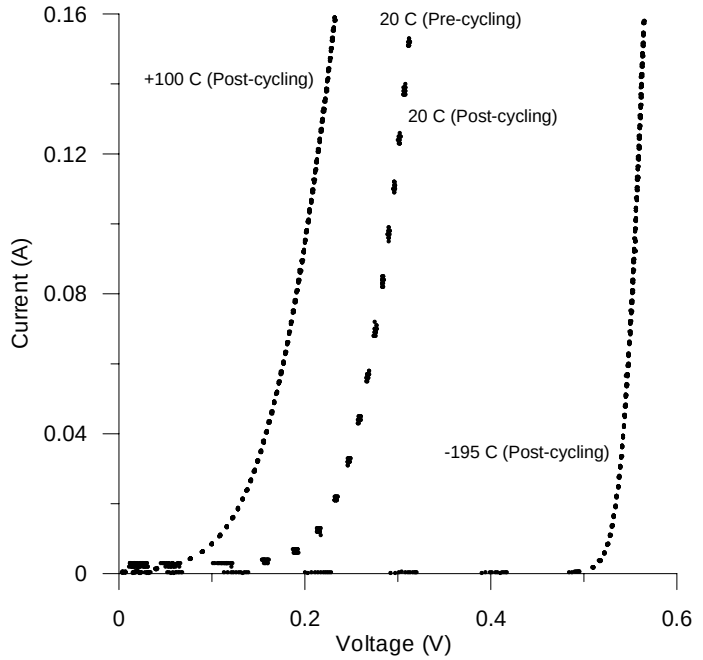

Figure 4. Forward V/I characteristics of a 1N5819 diode as a function of temperature.

Conclusions

Two devices of Fairchild's 1N4148 small signal diodes and 1N5819 Schottky rectifiers were evaluated for operation between -195 °C and +20 °C. The effects of thermal cycling under a wide temperature range on the operation of the diodes and cold-restart capability were also investigated. Both types of devices were able to maintain operation between -195 °C and +20 °C with minimal changes in their characteristics. The temperature-induced changes included an increase in forward voltage and a slight reduction in the on-resistance at cryogenic temperatures. At 100 °C, on the other hand, the forward voltage for both types of device exhibited a decrease. The limited thermal cycling performed on the devices had no effect on their performance, and all diodes were able to cold start at -195 °C. Further testing under long term cycling is required to fully establish the reliability of these devices and to determine their suitability for extended use in extreme temperature environments.

References

[1]. Fairchild Semiconductor Corporation, "1N4148 Small Signal Diode - Rev. B, 2002 & 1N5819 Schottky Rectifier - Rev. C, 2001" Data Sheets.

Acknowledgements

This work was performed under the NASA Glenn Research Center GESS Contract # NAS3-00145. Funding was provided by the NASA Electronic Parts and Packaging (NEPP) Program.